In the fourth and fifth articles (Taf. XIX-XXI) the author continues his already extensive studies on the spermatozoa of various animal groups, under the titles "Die Spermien der Cyclostomen" and "Noch einige Beiträge zur Kenntnis der Spermien bei den Affen," respectively.

"Die Gehirne der Affengattungen Cebus und Ateles" is without figures. It consists of some notes which supplement the author's earlier work, "Das Affenhirn in bildricher Darstellung," in which figures of these brains are found.

The final contribution "Die Verbindungen zwischen dem Sarcolemma und den Grundmembranen der Muskelfibrillen in bildricher Darstellung" (Taf. XVII, Fig. 25-27) is made up of three figures which represent the striated muscle of salamander larvæ, showing the finer structure of the muscle fibers and the relation of the ground membrane to the myofibrillæ and to the sarcolemma. Apparently a paper on this subject was contemplated by Retzius, but the text was not written. The editor refrains from supplying it, stating "Die Bilder demonstrieren selbst so gut diese Verhältnisse dass eine eingehende Erklärung nicht nötig ist. Prinzipiell will ich hier nicht versuchen, Wörte, die Retzius nicht selbst niedergeschrieben hat, ihm in den Mund zu legen." This statement admirably summarizes the attitude of the editor toward the contents of the entire volume.

The volume closes with an excellent table of contents of the two series of the Biologische Untersuchungen, namely, the two volumes which appeared in 1881 and 1882, and the nineteen volumes of the Neue Folge. Following this is a bibliography of the scientific works of Retzius, arranged by subjects. This bibliography consists of 333 titles.

It is fitting that the dedicatory page which in the preceding volumes has borne the names of so many distinguished anatomists should bear in the last volume the inscription by the widow of the author:

Dem Andenken meines verewigten Gemahls
GUSTAF RETZIUS
in Liebe und Dankbarkeit gewidmet.
Anna Hierta-Retzius.

To the sympathetic cooperation of his wife is due in no small measure, together with his own untiring zeal, the unique monument which Retzius has left in the nineteen folio volumes of the Biologische Untersuchungen, and the numerous other papers and monographs which bear his name.

O. LARSELL

UNIVERSITY OF OREGON
MEDICAL SCHOOL

SPECIAL ARTICLES

POLYPLOIDY, POLYSPORY, AND HYBRIDISM IN THE ANGIOSPERMS

FOR some time investigations have been carried on in these laboratories on the subject of polyploidy in relation to polyspory and hybridism. The material used consists of both Dicotyledons and Monocotyledons, and represents either known hybrids or species belonging to genera or groups in which a great deal of natural hybridism is suspected. The conclusion has been reached that polyploidy is a common result of incompatible species crosses. The normal gametophytic number of chromosomes becomes multiplied by three, four, etc., as a consequence of such inharmonious crosses, in various degrees of complexity. A frequent, although not invariable accompanying feature of polyploidy is the phenomenon of polyspory.

As is well known, the normal divisions taking place in the spore-mother cells of the Angiosperms, lead to the formation of four spores. Some of the members of the normal tetrad of spores may exceptionally abort, as for example, in the microspores of certain sedges. This condition of abortion is the normal one in the formation of megaspores. In the case of polyspory the first division of the spore-mother cell leads to the formation of more than the two normal daughter nuclei. Two larger nuclei are generally formed by the union of certain of the chromosomes which undergo separation into daughter groups at a moment preceding that in which the remaining chromosomes pass into the metakinetic phase. The later dividing chromosomes, in separating tardily into daughter groups are ordinarily

fewer in number than are those concerned in the formation of the two main daughter nuclei. The nuclear bodies formed by their fusion lie ultimately lateral to the spindle instead of terminal as in the case of the larger nuclei, and are of strikingly small size. There may be as many as four of the small nuclei at the end of the first division of the pollen mother-cells. When the second division takes place a further formation of normal large nuclei (aggregating four in number), and of abnormal small nuclei more numerous than are the large nuclei results. The large nuclei give rise usually to normal pollen grains but some or all of the grains resulting from them may abort. The small nuclei derived from the late-dividing and small groups of chromosomes give rise apparently always to abortive grains. A number of publications from this laboratory[1] have emphasized the importance of pollen sterility as a reliable morphological criterion of previous heterozygosis or genetical impurity.

Special attention has been devoted to abortive pollen as evidence of hybridism in the case of the Onagraceæ and Rosaceæ, but it is likewise found in many other groups. It is interesting to note that Tackholm in Sweden[2] and Blackburn and Harrison[3] in England, have recently pointed out the coincidence of hybridism and polyspory in the genus Rosa. Our investigations have made this condition clear for a considerable range of Dicotyledons and Monocotyledons. Tackholm has asserted on the basis of his extensive studies that all the roses belonging to the Canina section of the genus Rosa, in other words, the roses of Europe, of western Asia, and of northern Africa, are throughout hybrids probably thousands of years old and reproducing by apparently normal seeds, which are nevertheless formed "apomictically" and without the intervention of a sexual act. Obviously such seeds will "come true" as universally as do grafts or vegetative multiplications of any kind and for the same reason because they represent only subdivisions of the vegetative body.

Polyspory appears as a consequence of our investigations, which will be published in full at a later stage, as a frequent although not invariable result of hybridization of species (that is, of species crosses), and constitutes one more valuable structural or morphological criterion of heterozygosis. It frequently accompanies polyploidy and the manifestations of the so-called "lethal factor" in marked reproductive sterility in either known or suspected hybrids between species of the higher plants.

We have now the following morphological criteria of genetical impurity or heterozygosis in plants, namely, reproductive sterility (most easily observed in the case of the microspores or pollen), gigantism, variability (mutability), polyploidy and polyspory. Not all of these may occur in any given case, but the coincidence of any considerable number of these features should be regarded as supplying strong evidence of previous crossing of more or less incompatible species or varieties.

E. C. JEFFREY
A. E. LONGLEY
C. W. T. PENLAND
LABORATORIES OF PLANT MORPHOLOGY,
HARVARD UNIVERSITY

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